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THE UREDINEÆ OCCURRING UPON PHRAGMITES, SPARTINA, AND ARUNDINARIA IN AMERICA.[1]

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(WITH FOUR FIGURES)

UPON the several species of Phragmites, Spartina, and Arundinaria there occur in America one species of Uromyces and six species of Puccinia. There has never existed material confusion regarding the Uromyces species, except to divide it into two upon geographical grounds; but the Puccinia species have been so much confused and misunderstood that one may say with much truth that, whenever a correct determination has been made, it has been due more to good fortune than to clear insight. The most common disposition of these six species has been to list them indiscriminately under *P. Phragmitis* (Schum.) Körn., or possibly under *P. arundinacea* Hedw. or DC., or occasionally under *P. Arundinariæ* Schw. In 1876 Körnicke[2] showed that in Europe two species of Puccinia occur upon Phragmites that are morphologically distinguishable, which he diagnosed under the names *P. Phragmitis* and *P. Magnusiana*. The first of these species appears to be cosmopolitan and occurs in America, but not the second one. This second species is represented by a closely related one, however, which, together with the other four species of Puccinia and one of Uromyces described in this

[1] Presented by title at the Columbus meeting of the Botanical Society of America, Ag 1899.

[2] Hedwigia 15: 178. 1876.

paper, appears to be exclusively American. Several European species now known to occur upon Phragmites have not yet been found in America.

The writer's attention was first called to the confusion in the American species when studying the uredospores upon Spartina, preparatory to undertaking cultures. The results of subsequent study are now presented in systematic order, and with sufficient fullness, it is believed, to permit of the ready identification of material.

In this paper, whenever actual specimens are cited, the kind and abundance of the spores present are indicated by the cipher and Roman numerals: O. I. II. III. If the spore receptacles are well formed and fairly abundant, large (capital) type is used; and if the spores are few and subordinate, small (lower-case) type is used. Thus, II, iii, indicates that well-formed uredosori are present, but that the teleutosori are comparatively few, or that what teleutospores are present are borne in the uredosori.

Grateful acknowledgment is made to a number of mycologists for the loan of specimens. Professor T. J. Burrill of the University of Illinois, Professor L. H. Pammel of the Iowa State College, Professor W. G. Farlow of Harvard University, Professor L. R. Jones of the University of Vermont, Professor F. S. Earle of the Alabama Polytechnic Institute, and the custodians of the Philadelphia Academy of Sciences and the New York Botanical Gardens, placed a portion of the herbaria under their charge at my disposal; while the following botanists either loaned specimens from their herbaria or gathered material from the field for my use: Messrs. H. L. Bolley, R. I. Cratty, E. W. D. Holway, G. W. Carver, H. H. Hume, J. J. Davis, E. Bartholomew, S. M. Tracy, T. H. MacBride, P. H. Rolfs, L. M. Underwood, and C. E. Bessey. I am furthermore especially indebted to Mr. A. B. Seymour for the generous loan of a part of his herbarium, which proved remarkably rich in collections representing nearly all the species covered by this paper.

All figures accompanying this paper are drawn with camera

lucida to a uniform scale of 470 diameters, and all are in vertical section, excepting three uredospores which are in transverse section (see explanation of *figs. 3* and *4*). The pedicels are as carefully drawn as the rest of the spore.

1. UROMYCES ACUMINATUS Arth. 1883, May. Bull. Minn. Acad. Sci. 2:35.

SYN.: 1883, July. *Uromyces Spartina* Farl. Proc. Amer. Acad. Sci. 18: 77.

EXSICC.: Ellis, N. Amer. Fungi, 239[III], 1443[III].
Sydow, Uredineen, 251[III].
Seymour and Earle, Econ. Fungi, 67[III], 68[III], 546[III].

O. I. Spermogonia and aecidia unknown.

II. III. Sori epiphyllous, intercostal, linear, soon naked, ruptured epidermis conspicuous. II. Uredosori yellowish, inconspicuous; uredospores globose or broadly elliptical, large, 22–35μ in diameter, average 30μ, wall golden yellow, thick while immature, becoming thin, echinulate with low, stout points, pores 5 to 8, scattered. III. Teleutosori blackish-brown, sunken between the nerves or protruding; teleutospores dark brown, obovate or oblong-clavate, 15–22 by 25–40μ, apex darker, acuminate or obtuse, or with two or more projections, much thickened, 8–12μ, base narrowed, pedicel colored, firm, once to thrice length of the spore, often shorter.

From Massachusetts to Illinois and Nebraska and northward; especially abundant in the upper Mississippi valley. On leaves of the several species of Spartina; the uredospores in July, soon followed by the teleutospores, which persist through the winter and germinate the following spring. Specimens have been examined as follows:

On *Spartina cynosuroides* (L.) Willd. 1881, III, Illinois (1326, *A. B. Seymour*); Sept. 1882, III, Ft. Dodge, Iowa (type of *Urom. acuminatus* Arth., *J. C. Arthur*); Nov. 1882, III, Decorah, Iowa (*E. W. D. Holway*); Dec. 1882, III, Spirit lake, Iowa (*J. C. Arthur*); July 1883, II, Spirit lake, Iowa (*J. C. Arthur*); Sept. 1883, III, Decorah, Iowa (Ellis, N. Am. Fungi, 1443, *E. W. D. Holway*); Dec. 1883, III, Spirit lake, Iowa (*J. C. Arthur*); Aug. 1884, III, Bismarck, N. D. (Journey to Washington Territory, 297, 298, *A. B. Seymour*); Aug. 1884, III, Valley city, N. D. (Journey to Washington

Territory, 299, *A. B. Seymour*); Sept. 1884, III, Decorah, Iowa (*E. W. D. Holway*); Oct. 1885, III, Decorah, Iowa (Sydow's Uredineen, 251, *E. W. D. Holway*); July 1886, II. iii, Emmet co., Iowa (*R. I. Cratty*); Aug. 1886, III, Emmet co., Iowa (524, *R. I. Cratty*); Oct. 1888, III, Racine, Wis. (*J. J. Davis*); Aug. 1898, II. iii, Spirit lake, Iowa (*J. C. Arthur*); April 1899, III, Ames, Iowa (Cryptogams: Plants of Iowa distributed by the Iowa State College, 47, *H. H. Hume*); July 1899, II. III, Fargo, N. D. (*H. L. Bolley*); Aug. 1899, ii. III, Long Pine, Neb. (*J. M. Bates*); Oct. 1901, III, Fargo, N. D. (*H. L. Bolley*); no date, ii. III, Canada (1193, *C. G. Pringle*).

On *Spartina gracilis* Trin. Sept. 1884, III, Medora, N. D. (Journey to Washington Territory, *A. B. Seymour*); July 1901, II. III, Gleichen, Alberta, Can. (*E. W. D. Holway*).

On *Spartina glabra* Muhl. No date, II. III, Woods Hole, Mass. (Ellis' N. Amer. Fungi, 239, type collection of *Urom. Spartinæ* Farl., *W. G. Farlow*); Oct. 1889, III, Cambridge, Mass. (Seymour and Earle's Economic Fungi, 68, *A. B. Seymour*).

On *Spartina patens* (Ait.) Muhl. Oct. 1889, III, Cambridge, Mass. (Seymour and Earle's Econ. Fungi, 67, *A. B. Seymour*); Sept. 1899, ii, III, Portland, Me. (*J. C. Arthur*).

The species apparently finds its greatest development, judging by the abundance of the teleutosporic stage, in the prairie region of the upper Mississippi valley and northward, although, judging by the fullness and prominence of the sori and plumpness of the spores, it flourishes best along the northern Atlantic shores. No one has yet been able to suggest the probable aecidial stage, which should be known before pronouncing upon the conditions best suited to the species. Dr. W. G. Farlow,[3] in notes on the first collection made at the seashore, mentions his failure to find any aecidium in the vicinity that could reasonably be associated with it, and several times in northern Iowa, where the species is especially abundant, the writer has made careful search for a related aecidium, but wholly in vain.

The teleutospores of this species, as well as their sori, are quite variable (*fig. 1, a* to *e*). Collections made from salt marshes near the sea, which have heretofore been called *Urom. Spartinæ* Farl., have the sori prominent, and the teleutospores with more rounded apices, and, in general, a deeper-colored, more luxuriant appearance (*fig. 1, c*). This richer development

[3] Proc. Amer. Acad. Sci. 18: 77.

also extends somewhat to the uredospores, which generally are larger and have thicker walls. But these characteristics are not wholly absent from inland specimens. They are quite as well shown in both sori and spores in two collections from Alberta and North Dakota in the northwest, both on *Spartina gracilis* (*fig. 1, e*), and also, so far as the spores are concerned, in a specimen from Nebraska (Bates, Aug. 1899) and one from Wisconsin (Davis, Oct. 1888), both on *S. cynosuroides* (*fig. 1, b* and *d*). The latter specimen is in the herbarium of Mr. A. B. Seymour,

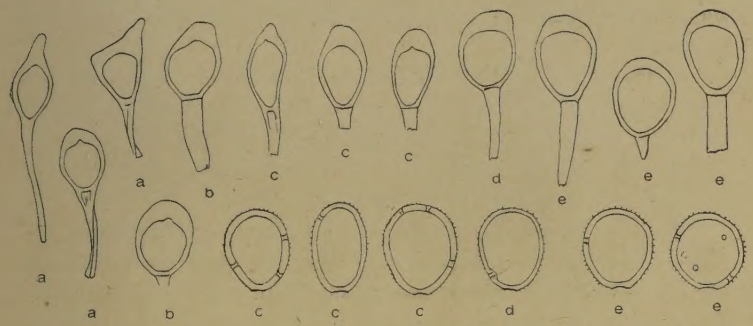

FIG. 1.—*U. acuminatus*: *a*, three teleutospores showing size and diverse forms common on the western prairies, on *Spartina cynosuroides* from Iowa; *b*, two teleutospores on same host from Wisconsin (Davis, 1888); *c*, three uredospores and three teleutospores of the typical *U. Spartinae* Farl. common along the seashore, on *Spartina glabra* from Woods Hole, Mass.; *d*, one uredospore and one teleutospore on *Spartina cynosuroides* from Nebraska (Bates, Aug. 1899); *e*, two uredospores and three teleutospores on *Spartina gracilis* from Alberta (Holway, 1901).

and is accompanied by the following note, probably made by the collector: "Has the large, blunt-warted uredospores of *Urom. Spartinæ*, but hardly the long and broad pedicels of the teleutospores, nor the large, elongated sori; it has darker and more rounded teleutospores than *Urom. acuminatus*." This note brings out clearly the distinctions that have been maintained between the two forms.

Of the variability of the teleutospores of the inland form Burrill[4] makes the following observations (*fig. 1, a*): "Among

[4] Parasitic fungi of Illinois, Bull. Ill. Lab. Nat. Hist. **2**: 169.

the Uromycetes inhabiting grasses this is readily distinguished by the irregular and peculiar shape of the teleutospores; while some are no longer than wide, many are oblong or nearly lanceolate, while the apex has a multitude of forms; sometimes straight, sometimes acutely acuminate, often turned sidewise, beak-like, not seldom double, and occasionally suggesting the appendages at the apex of the teleutospores of *Puccinia coronata*." The paler, more slender, and poorly nourished teleutospores of the inland form are associated with the smaller sori, which are sunken and compressed between the stout nerves of the leaves.

If there are specific differences between the seashore and inland forms of this rust, they can only be established with certainty by cultures. Morphological characters derived from the uredo and teleuto stages show no differences that are not accounted for by ecological conditions.

The species was first recorded by Farlow[5] in 1878 under the name *Urom. Junci*. The following year the same collection was distributed in Ellis' *North Amer. Fungi*, No. 239, under the name *Urom. Junci* var. *Spartinæ*, but without description. Later study resulted in raising the form to specific rank, as given in the synonymy above.

2. PUCCINIA FRAXINATA (Lk.), nom. nov.

SYN.: 1822. *Aecidium Fraxini* Schw. Schrift. d. nat. Ges. zu Leipzig 1:66.

1825. *Caeoma Fraxinatum* Link. Linné Sp. Pl. 6^2: 62.

1834. *Caeoma* (*Roestelia*) *Fraxinites* Schw. Trans. Amer. Phil. Soc. 4:294.

1890. *Uredo peridermiospora* E. & T. Jour. Myc. 6:77.

1896. *Puccinia sparganioides* E & B. Erythea 4:2.

1899. *Puccinia peridermiospora* Arth. Science 10:565.

EXSICC.: Ellis and Everhart, N. Amer. Fungi, 1851^{III}, 3475^{III}.
Ellis and Everhart, Fungi Columb., 1288^{III}.
Carleton, Ured. Amer., 33^{I}.
Sydow, Uredineen, 262^{III}, and 1167^{III}.

O. I. Spermogonia epiphyllous, yellow, inconspicuous;

[5] Bull. Bussey Inst. 2:225 and 243.

spermatia obovate or oblong, about 3 by 5 μ. Aecidia hypophyllous, or on petioles and fruit, in dense rounded groups, usually on swollen and discolored spots; peridia cylindrical, often elongated, margin lacerated; aecidiospores obovate or elliptical, 22–26 by 33–37 μ, contents orange when fresh, becoming faintly yellow when old, wall colorless, thin at the sides but greatly thickened at the obtuse apex, tuberculate.

II. III. Sori hypophyllous, amphigenous on some hosts, supercostal, very prominent, large, oblong, elongated on sheaths and culms, ruptured epidermis attached in shreds or disappearing. II. Uredosori pulverulent, at first bright orange, becoming yellowish and indistinct; uredospores obovate or elliptical, 22–30 by 33–44 μ, contents orange when fresh, becoming faintly yellow when old, wall colorless, thin at the sides but greatly thickened at the rounded apex, prominently tuberculate, pores obscure. III. Teleutosori pulvinate, blackish-brown; teleutospores elliptical or oblong, 16–22 by 35–62 μ, dark brown, slightly constricted at the septum, apex obtuse, thickened; pedicel firm, slender, tinted, once to twice the length of the spore

Common throughout the United States and Canada east of the Rocky mountains. On leaves, petioles, and fruiting inflorescence of the various species of Fraxinus and Spartina; spermogonia and aecidia May to July, uredo in July and August, followed shortly by the teleutospores, which persist through the winter and germinate the next spring. Specimens have been examined as follows:

On *Fraxinus lanceolata* Borck. (*F. viride* Michx.) May 1871, O. I, Ames, Iowa (*J. C. Arthur*); July 1883, O. I, Spirit lake, Iowa (*J. C. Arthur*); 1886, I, Washington, D. C. (collector not recorded); June 1892, O. I, Rockport, Kan. (*E. Bartholomew*); June 1892, I, Manhattan, Kan. (Carleton's Ured. Amer., 33, *M. A. Carleton*); Aug. 1898, I, Heron lake, Minn. (*J. C. Arthur*); May and June 1899, O. I, Lafayette, Ind. (grown from teleutospores on *Spartina* by the writer, *J. C. Arthur*); June 1899, I, Ames, Iowa (*H. H. Hume*); July 1899, I, Spirit lake, Iowa (*J. C. Arthur*); Aug. 1899, I, South Hero, Vt. (*L. R. Jones*); June 1900, O. I, Spirit lake, Iowa (*J. C. Arthur*); July 1901, I, Crow agency, Mont. (237, *J. W. Blankinship*).

On *Fraxinus Americana* L. June 1889, O. I, Iowa city, Iowa (*Mrs. M. F. L. Fitzpatrick*).

On *Fraxinus Pennsylvanica* Marsh. (*F. pubescens* Lam.). June 1899, O. I, Long pine, Neb. (*J. M. Bates*); Aug. 1899, I, South Hero, Vt. (*L. R. Jones*).

On *Fraxinus nigra* Marsh. (*F. sambucifolia* Lam.). July 1884, o. I, La Crosse, Wis. (*L. H. Pammel*).

On *Fraxinus* sp. indet. No date, o. i, Bethlehem, Pa. (Type of *Æcid. Fraxini* Schw., *L. von Schweinitz*).

On *Spartina cynosuroides* (L.) Willd. Aug. 1882. III, Charles city, Iowa (*J. C. Arthur*); Oct. 1882, III, Ames, Iowa (*J. C. Arthur*); Oct. 1882, III, Urbana, Ill. (6335, *A. B. Seymour*); Oct. 1882, III, Ames, Iowa (*J. C. Arthur*); Nov. 1882, III, Decorah, Iowa (*E. W. D. Holway*); Dec. 1883, III, Spirit lake, Iowa (*J. C. Arthur*); Aug. 1884, III, Bismarck, N. D. (Jour. to Wash. Terr., *A. B. Seymour*); Oct. 1885, III, Decorah, Iowa (*E. W. D. Holway*); Oct. 1885, III, Urbana, Ill. (*M. B. Waite*); Oct. 1889, III, Decorah, Iowa (Sydow's Ured., 262, *E. W. D. Holway*); Oct. 1890, III, Racine, Wis. (*J. J. Davis*); Oct. 1892, III, Brookings, S. D. (*David Griffiths*); Oct. 1892, III, Ames, Iowa (*G. W. Carver*); Aug. 1895, ii. III, Rooks co., Kan. (Type of *Puc. sparganioides* E. & E., 1908, *E. Bartholomew*); Aug. 1897, III, Rooks co., Kan. (Ellis and Everhart's Fungi Columb., 1288, *E. Bartholomew*); Oct. 1897, III, Rooks co., Kansas (*E. Bartholomew*); July and Aug. 1898, II. III, Spirit lake, Iowa (*J. C. Arthur*); Oct. 1898, III, Alburgh, Vt. (*W. A. Orton*); April 1899, III, Lincoln, Neb. (in part used by the writer for successful cultures on Fraxinus, *W. T. Horne*); May 1899, III, Fargo, N. D. (*H. L. Bolley*); May 1899, III, Ames, Iowa (in part used by the writer for successful cultures on Fraxinus, *H. H. Hume*); July 1899, II. III, Fargo, N. D. (*H. L. Bolley*); Aug. 1899, II. iii, Ames, Iowa (*H. H. Hume*); Aug. 1899, III, South Hero, Vt. (*L. R. Jones*); Aug. 1899, III, O'Neill, Neb. (*J. M. Bates*); Oct. 1900, III, Orono, Me. (*R. L. Ricker*); No date, III, Stillwater, Okla. (*E. E. Bogue*); No date, III, Ft. Dodge, Iowa (*J. C. Arthur*).

On *Spartina glabra* Muhl. Sept. 1889, II, Ocean springs, Miss. (type of *Uredo peridermiospora* E. & T., *S. M. Tracy*).

On *Spartina polystachya* (Michx.) Willd. Oct. 1886, III, Point a la Hache, La. (Ellis and Everhart's N. Am. Fungi, 1851, *A. B. Langlois*); No date, III, no locality (Ravenel's Fungi Caroliniani, 89, no collector recorded).

On *Spartina patens* (Ait.) Muhl. 1891, III, Salem, N. J. (*A. Commons*); Sept. 1898, III, Madison, Conn. (2067, *T. E. Hazen*).

In many parts of the country, especially in the upper Mississippi valley, this species is one of the most abundant of plant

rusts, both on Spartina and Fraxinus. Bessey[6] records that in 1885 it infested the green ash trees about Lincoln, Neb., to such a degree as to attract the attention of casual passers.

The teleutosporic form is equally common with the aecidial, and is well represented in herbaria, where it has passed under the name of *Puc. Phragmitis* for the most part. It was not until the publication of the result of cultures by the writer[7] about two years ago, that the autonomy of the species was recognized.

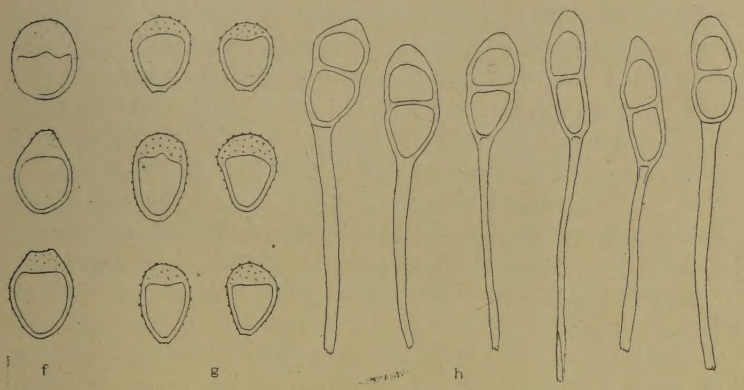

FIG. 2.—*P. Fraxinata: f*, three aecidiospores on *Fraxinus lanceolata; g*, six uredospores, and (*h*) six teleutospores, both on *Spartina cynosuroides*.

The uredo form is very rarely collected, and the writer has had much difficulty to secure material for study. The sori are rather conspicuous when they first appear, but are usually not abundant, and are soon replaced by the teleutospores.

The aecidiospores and uredospores show a very remarkable similarity in color, form, and markings (*fig. 2, f* and *g*). Both have colorless walls, greatly thickened at the apex, and evenly tuberculate. The contents are of the same shade of orange, a color that speedily disappears with the death of the protoplasm. In fact the uredospores differ in appearance from the aecidiospores chiefly in being a little more robust. The shape and dimensions in the diagnosis above are for the spores when seen

[6] Amer. Nat. 19: 886; see also *ibid.* 20: 806. [7] BOT. GAZ. 29: 275.

from the side, that is, in vertical section, making the description of both forms comparable with that of the teleutospores (*fig. 2, h*).

On Spartina this rust occurs exclusively on the hard and smooth surfaces of the plant; the under (smooth) side of the blade, the sheaths, and the exposed parts of the internodes. On *Spartina polystachya* and *S. glabra* it grows equally well on both surfaces of the blade. This difference of habit is correlated with the fact that in these two hosts the hard tissues of the leaf are almost equally well developed upon both sides of the blade, so much so as to prevent the leaf from becoming much convolute upon drying, as it does in the other species of the genus.

The writer is fortunate in having been able to examine all the type material upon which the synonymy of the species is based. The type of *Æcidium Fraxini* Schw., which is in the Schweinitz collection at the Philadelphia Academy of Sciences, consists of a single leaf, bearing thirteen round groups of aecidia. The spots are much swollen, but too young to show open peridia. The type material of *Uredo peridermiospora* Ellis & Tracy consists of the bases of two similar leaves of *Spartina glabra* Muhl., one of which is in the herbarium of Mr. S. M. Tracy, the collector, and the other is in the Ellis herbarium at the New York Botanical Gardens. In the packet at the latter place is the following unsigned note: "Spor. pyriform, $35-45 \times 18-22\ \mu$, contents orange-red with a hyaline envelop, which is at first subtubercular-roughened, but finally becomes smooth or nearly so. The spores are much like those of *Peridermium pyriforme* Pk." The type of *Puccinia sparganioides* E. & E. is in the Ellis herbarium at the New York Botanical Gardens. It consists of quite a number of portions of leaves, each about 10^{cm} long, all well covered with uredo- and teleutosori, and is accompanied by diagnostic and other notes. The host was at first supposed to be *Carex sparganioides*, and was so stated in connection with the original description, and hence the specific name; it was afterward thought to be *Carex stricta*, and is so labeled in Ellis and Everhart's N. Amer. Fungi, no. 3475; finally the host was

determined as *Spartina cynosuroides*, and the correction published by Bartholomew[8] in his list of Kansas Uredineae. All the synonyms of the species are founded upon these three types.

The oldest specific name, *Fraxini*, cannot be transferred to the genus Puccinia, as there is already a *P. Fraxini* Kom. from the orient,[9] and the next oldest name, that of Link, is therefore taken.

3. **Puccinia Seymouriana**, sp. nov.

Exsicc: Ellis & Everhart, N. Am. Fungi, 1474 III.
Seymour & Earle, Econ. Fungi, 69 III.

O. I. Spermogonia and aecidia unknown.

II. III. Sori epiphyllous, intercostal, prominent, oblong, ruptured epidermis inconspicuous. II. Uredospores globose, or broadly elliptical, 26–39 by 30–45 μ, contents orange when fresh, becoming faintly yellow when old, at first globose, afterward angular and shrunken, wall colorless, thickened above, sometimes to more than half the diameter of the spore, prominently tuberculate, pores obscure. III. Teleutosori pulvinate, chocolate brown; teleutospores elliptical or oblong, 20–26 by 37–52 μ, slightly constricted at the septum, apex obtuse, thickened; pedicel firm, slender, tinted, once to thrice the length of the spore.

From Massachusetts to Illinois and Iowa, and northward. On blades of *Spartina cynosuroides;* uredospores in July, soon followed by the teleutospores which persist through the winter and germinate the next spring. Specimens have been examined as follows:

On *Spartina cynosuroides* (L.) Willd. July 1881, III, Hudson, Ill. (2348, *A. B. Seymour*); Aug. 1881, III, English prairie, Ill. (1346, *A. B. Seymour*); Oct. 1881, III, Canton, Ill. (1771, *A. B. Seymour*); Oct. 1881, May and Sept. 1882, III, Normal, Ill. (1829, 4794, 6262, *A. B. Seymour*); June 1882, III, Normal, Ill. (5272, *C. A. Hart*); Jan. and March 1883, III, Normal, Ill. (*C. A. Hart*); April 1883, III, Madison, Wis. (*Wm. Trelease*); Oct. 1883, III, Chicago, Ill. (*J. C. Arthur*); Nov. 1883, III, Normal, Ill. (Ellis & Ever-

[8] Trans. Kan. Acad. Sci. 16: 178.

[9] See Jaczewski, Komarov, Tranzschel, Fungi Rossiae Exsiccati, no. 225, where full description is given.

hart's N. Am. Fungi, 1474, *A. B. Seymour*); Aug. 1884, III, Bismarck, N. D. (Jour. to Wash. Terr., 296, 302, *A. B. Seymour*); Oct. 1890, III, North Weymouth, Mass. (Seymour & Earle's Econ. Fungi, 69, *L. M. Underwood*); Aug. 1896, III, Pt. Abino, Ontario. (*S. M. Tracy*); Sept. 1899, ii. III, Racine, Wis. (type collection, *J. J. Davis*); April 1899, Mar. and April 1900, April 1901, III, Racine, Wis. (*J. J. Davis*); No date, III, Ames, Iowa (*L. H. Pammel.*

In naming this very distinct new species I take pleasure in recognizing the services of Mr. A. B. Seymour in the cause of mycological science. One-third of the collections of this species that I have been enabled to study, coming from various sources, were made by him, and it was during my examination of the material in his private herbarium, kindly placed at my disposal, that I became aware of the existence of the species, which has heretofore been an unrecognized part of the preceding one.

The species is separable from *P. Fraxinata*, and recognizable with considerable ease, by the position of the teleutosporic sori on the rough side of the leaf, emerging from between the nerves. They are usually a little lighter in color also. But the final reliance must be upon the uredospores (*fig. 3, k*), which are very distinctive, and a few of which may almost invariably be found intermixed with the teleutospores (*fig. 3, l*), at whatever season of the year the material may have been gathered. The shrunken contents lying at the base of the spore, and the colorless, tuberculate wall, gives the spores a wholly unique appearance among gramineous species.

Attempts at cultures have been made for three seasons past, but so far in vain. At first the efforts were misdirected from lack of any but the vaguest geographical clues. After detecting and establishing a connection between morphological similarity in uredo and aecidium and also a specific relationship in the preceding species, I searched through the herbarium for some aecidiosporic form having colorless, tuberculate walls, and angularly shrunken contents, and was rewarded by finding that *Æcidium Cephalanthi* Seym. possessed exactly these characters. Its geographical range is also that of *P. Seymouriana*, so far as the two are known. In the spring of 1901 I was possessed of

this information and the necessary material, but was frustrated by failure of the teleutospores to germinate. The preceding winter seems, for some unknown reason, to have been destructive of many plant rusts. Not only this species, but *P. Asparagi*, *P. lateripes*, *P. emaculata*, *P. vexans*, and many others could not be made to germinate, showing that the spores had winter-killed. Although cultures must be awaited, yet there can be little doubt that the early stages of *P. Seymouriana* occur upon Cephalanthus.

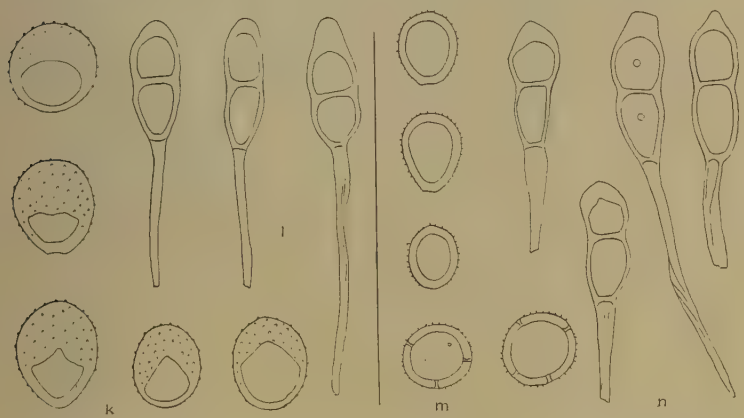

FIG. 3.—*P. Seymouriana: k*, four uredospores, and (*l*) three teleutospores, on *Spartina cynosuroides*. *P. Distichlidis: m*, five uredospores, the two lowermost shown in transverse optical section, and (*n*) four teleutospores, both on *Spartina gracilis*.

4. PUCCINIA DISTICHLIDIS E. & E. 1893. Proc. Phil. Acad. Sci. 1893: 152.

SYN.: 1898. *Dicaeoma Distichlidis* Kuntze. Rev. Gen. Pl. 3: 468.

O. I. Spermogonia and aecidia unknown.

II. III. Sori epiphyllous, intercostal, early naked, ruptured epidermis conspicuous. II. Uredospores broadly elliptical, broadly obovate or globose, 26–32 by 27–40 μ, wall pale yellow, thick, abundantly echinulate with stout points, pores six or more, scattered, indistinct, contents sometimes centrally shrunken. III. Teleutosori blackish, prominent, linear-lanceolate with acute ends; teleutospores obovate or lance-oblong, 17–21 by 48–56 μ,

slightly constricted at the septum, apex obtuse or subacute, thickened, side walls thin, base somewhat narrowed, pedicel firm, rather thick, tinted, as long as the spore or longer.

From Montana to North Dakota and Iowa. On blades of *Spartina;* uredospores in July, soon followed by the teleutospores, which persist through the winter. Specimens have been examined as follows:

On *Spartina gracilis* Trin. Oct. 1888, III, Ten-mile creek, Mont. (*F. W. Anderson*); Oct. 1888, III, Helena, Mont. (185 *F. W. Anderson*); Oct. 1888, III, Helena, Mont. (F. D. Kelsey); Aug. 1890, ii. III, Helena, Mont. (*F. D. Kelsey*); Sept. 1891, III, Helena, Mont. (type collection, *F. D. Kelsey*); Aug. 1901, III, near Laramie, Wyo. (1219, *Elmer D. Merrill* and *E. N. Wilcox*).

On *Spartina cynosuroides* (L.) Willd. Aug. 1884, III, Valley city, N. D. (Journey to Wash. Terr., *A. B. Seymour*); Aug. 1886, III, Emmet co., Iowa (544 *R. I. Cratty*); May 1899, III, Fargo, N. D. (*H. L. Bolley*); July 1899, II. III, Fargo, N. D. (*H. L. Bolley*).

This species was described some time ago, but its true character and position have remained unrecognized, on account of error in determination of the host, which was said to be *Distichlis maritima*, and hence the specific name. The unfortunate mistake has led to much confusion, as many collections on Distichlis have been given this name by wrong assumption, and many unwise comparisons made.

The type is in the Ellis collection at the New York Botanical Garden. It consists of several portions of leaves, each about 8^{cm} long, well covered with teleutosori. It was gathered September 21, 1891, at Helena, Mont., by Rev. F. D. Kelsey. In the herbarium of Mr. A. B. Seymour are two other collections from the type locality, and in the herbarium of Dr. W. G. Farlow is a fourth collection from the same locality. A comparison of these several collections, one (Anderson's No. 185) being accompanied with inflorescence, leaves not the shadow of a doubt that the host for all of them is *Spartina gracilis* Trin. There is, however, a *Puccinia subnitens* Diet., a wholly distinct species, which does occur upon *Distichlis maritima*.

The pointed extremities of the teleutosori, and the large

echinulate uredospores, with uncontracted or occasionally centrally contracted contents, well distinguish this species from other Spartina rusts (*fig. 3*, *m* and *n*).

5. PUCCINIA RUBELLA (Pers.), nom nov.

SYN.: 1791. *Aecidium rubellum* Pers. Linné Syst. Nat. cur. Gmelin 2 : 1473.

1796. *Aecidium Rumicis* Hoffm. Bot. Taschenb. 2 : —.

1803. *Uredo Phragmitis* Schum. Fl. Saell. 2 : 231.

1808. *Puccinia arundinacea* Hedw. Lam. and DC., Encycl. 8 : 250.

1810. *Uredo striola* Strauss. Wetter. Annal. 2 : 105.

1827. *Uredo rubella* Spreng. in part. Syst. Veg. 4 : 572.

1876. *Puccinia Phragmitis* Körn. Hedw. 15 : 179.

1898. *Dicaeoma Phragmitis* Kuntze. Rev. Gen. Pl. 3 : 470.

EXSICC.: Sydow, Ured., 278[I], 576[III], 679[I], 680[I], 779[I], 924[I].
Seymour and Earle, Econ. Fungi, 70[III].
Carleton, Ured. Amer. 36[III].
Eriksson, Fungi Par. Scand. Exsicc., 169[I].
Linhart, Fungi Hungar., 26[II III], 37[i].
Vize, Fungi Brit., 124[III], 161[I].
Thuemen, Myc. univ., 630[I].

O. I. Spermogonia not observed. Aecidia small, hypophyllous, on purple-red, somewhat swollen spots, in rounded, often circinating groups, peridia white, low, with reflexed, much split border, aecidiospores polygonal, 17–25 μ in diameter, nearly colorless, wall rather thin, finely tuberculate.

II. III. Sori amphigenous, prominent, oblong, elongated on sheaths and stems, ruptured epidermis inconspicuous. II. Uredosori, brownish-yellow, pulverulent, without paraphyses; uredospores elliptical or obovate, 19–24 by 27–36 μ, wall thick, golden yellow, tuberculate, pores four, equatorial. III. Teleutosori very prominent, blackish-brown; teleutospores oblong, rounded or obtuse at both ends, slightly constricted at the septum, 18–24 by 45–64 μ, side walls rather thick, apex a little thickened, pedicel firm, slender, strongly tinted, very long, two to five times the length of the spore.

The northern United States east of the Rocky mountains, and Europe. Early stages on several species of Rumex, not yet collected in America, but cultivated from American teleuto-

spores, and also on Rheum ; later stages on Phragmites. Besides many European specimens the following from America have been examined:

On *Rumex crispus* L. May, 1899, I, Lafayette, Ind. (cultivated by the writer from teleutospores sent from Wisconsin and Nebraska.)

On *Rumex obtusifolius* L. May, 1899, I, Lafayette, Ind. (cultivated by the writer from teleutospores sent from Wisconsin and Nebraska.)

On *Rheum Rhaponticum* L. June, 1901, Kearney, Neb. (1822, *J. M. Bates*).

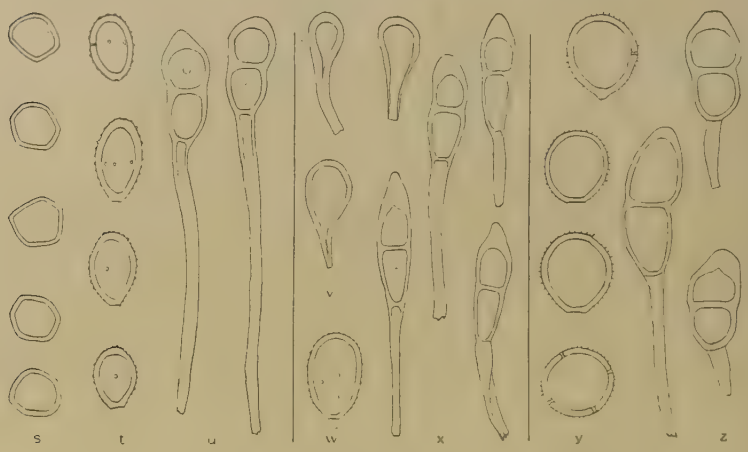

FIG. 4.—*P. rubella: s*, five aecidiospores on *Rumex obtusifolius*, cultivated; *t*, four uredospores, and (*u*) two teleutospores, both on Phragmites. *P. simillima: v*, three paraphyses from uredosori; *w*, one uredospore; *x*, four teleutospores, all on Phragmites. *P. Arundinariae: y*, four uredospores, the lowermost in transverse section; *z*, three teleutospores, both on Arundinaria.

On *Phragmites Phragmites* (L.) Karst. (*P. communis* Trin.) Aug. 1881, III, McHenry, Ill. (1325, *A. B. Seymour*); Aug. 1881, III, Elgin, Ill. (1368, *A. B. Seymour*); Oct. 1884, III, Mason city, Ia. (*E. W. D. Holway*); Oct. 1885, III, Decorah, Ia. (*E. W. D. Holway*); July, 1886, II. III, Vermilion lake, Minn. (137, *E. W. D. Holway*); Oct. 1892, III, Coolidge, Kan. (Carleton's Ured. Amer., 36, *M. A. Carleton*); Nov. 1893, III, Wilmington, Del. (*A. Commons*); Apr. 1899, III, Racine, Wis. (partly used by the writer for successful cultures on Rumex, *J. J. Davis*); May, 1899, III, Lincoln, Neb. (partly used by the writer for successful cultures on Rumex, *C. E. Bessey*); 1901, III, Callaway, Neb. (1658, *J. M. Bates*).

This cosmopolitan species shows no American peculiarities (*fig. 4, s, t,* and *u*) except the great rarity of the aecidial form. The teleutospores, however, are strongly viable, and grow readily on *Rumex crispus* and *R. obtusifolius*, forming normal aecidia exactly like those collected in the open in Europe.[10] The aecidia, which are small, colorless, and inconspicuous, have so far only been found once with certainty in America.

The reasons for selecting the name here adopted should probably be stated. There is no question but that Persoon's *Æcidium rubellum* included the aecidial form of this species of Puccinia, and that it is the oldest name. His diagnosis ran as follows: "*Ae. rubrum. α rumicis, thecis congestis seminibusque albis. β grossulariæ, thecis sparcis seminibusque pallidis.*" The name might evidently have been written *P. Rumicis*, had that name not already been applied elsewhere. In writing *P. rubella* it is assumed that, when all the forms composing a species are serially separated, as indicated by letters or otherwise, the specific name covers the first of these varieties, whether this first variety is given a distinctive name or not. If in such a case the varieties are erected into species, the first one may bear either the specific or the first varietal name.

6. **Puccinia simillima,** sp. nov.

Exsicc.: Sydow, Ured., 274 III in part.

O. I. Spermogonia and æcidia uncertain.

II. III. Sori amphigenous, low and rather small, oblong, elongated on sheaths, ruptured epidermis somewhat noticeable. II. Uredosori light yellow, pulverulent, with clavate paraphyses; uredospores obovate or oblong-clavate, 18–22 by 26–44 μ, wall of medium thickness, golden yellow, minutely tuberculate and sometimes slightly echinulate, pores indistinct, scattered, number undetermined. III. Teleutosori small, very numerous, nearly or quite black; teleutospores at first arising from the uredosori, linear-oblong or oblong-lanceolate, very little constricted at the septum, 15–20 by 42–56 μ, base narrowed, side walls thin, apex acuminate, acute or less often obtuse, thick-

[10] Arthur, Bot. Gaz. 18: 269–270. Ap 1900.

ened up to 15 μ, pedicel firm, thick, the length of the spore more or less.

Iowa and Wisconsin. On blades and sheaths of Phragmites; uredospores in July, soon followed by teleutospores, which persist through the winter. Specimens have been examined as follows:

On *Phragmites Phragmites* (L.) Karst. (*P. communis* Trin.) Dec. 1883, III, Spirit lake, Ia. (*J. C. Arthur*); Oct. 1884, III, Mason city, Ia. (*E. W. D. Holway*); Oct. 1885, III, Decorah, Ia. (Sydow's Uredineen, 274, *E. W. D. Holway*); Sept. 1892, III, Ames, Ia. (*G. W. Carver*); Aug. 1898, II. iii, Spirit lake, Ia. (type, *J. C. Arthur*); May 1899, III, Armstrong, Ia. (*R. I. Cratty*); Sept. 1901, III, Racine, Wis. (*J. J. Davis*).

This species probably has a wider distribution than the above series of specimens indicate, as it is likely to have been overlooked. It occurs frequently intermixed upon the same leaves with *P. rubella*. This was the case with all the above collections, except those from northwestern Iowa, at Spirit lake and Armstrong.

Cultures have not yet been made, but there are the strongest reasons, based upon field observations, for believing that the aecidial stage occurs upon *Anemone Canadensis* L. (*A. Pennsylvanica* L.).

The species is very closely related to *P. Magnusiana* Körn.; and even the supposed aecidial stage on Anemone resembles the aecidial form of that species on *Ranunculus repens* and *R. bulbosus*. It is distinguished, however, by the slender, pointed teleutospores, and by the more clavate and less roughened uredospores, and probably by the aecidial host (*fig. 4*, *w* and *x*).

7. PUCCINIA ARUNDINARIAE Schw. 1822. Schrift. d. Nat. Ges. zu Leipzig 1:72.

SYN.: 1898. *Dicaeoma Arundinariae* Kuntze. Rev. Gen. Pl. 3:467.

O. I. Spermogonia and aecidia unknown.

II. III. Sori hypophyllous, rather small, nearly round, early naked, ruptured epidermis inconspicuous. II. Uredosori cinnamon-brown, pulverulent, without paraphyses; uredospores large, broadly elliptical or globose, 24–32 μ in diameter, wall

rather thin, brownish-yellow, sparingly echinulate with stout points, pores indistinct, apparently four and equatorial. III. Teleutosori pulvinate, solid, blackish brown; teleutospores dark brown, linear-oblong, 20–24 by 48–72 μ, not constricted at the septum, side walls moderately thick, apex somewhat thickened, obtuse or rounded, pedicel slender, firm, slightly tinted or colorless, as long as the spore, more or less.

In the southern states from North Carolina to Alabama, not common. On leaves of Arundinaria. Specimens have been examined as follows:

On *Arundinaria tecta* (Walt.) Muhl. No date, III, Salem, N. C. (type, *L. Von Schweinitz*); Feb. 1896, III, Auburn, Ala. (*F. S. Earle* and *L. M. Underwood*); Sept., 1897, III, Tuskegee, Ala. (95, *G. W. Carver*); Sept. 1899, II, iii, Clemson College, S. C. (54, *P. H. Rolfs*); Dec. 1900, III, Clemson College, S. C. (*P. H. Rolfs*).

This is not an abundant species. Although collected by L. von Schweinitz in North Carolina about 1820, and again later in Philadelphia, Penn.,[11] on plants in the Bartram Gardens, brought from a distance, yet it has been rarely collected since. It appears to occur over a wide area, but at all times very sparingly. The uredo stage, being light brown in color, is especially difficult to find. I am indebted to Mr. P. H. Rolfs and Mr. George W. Carver for material for study, which they obtained for me after much search.

The type specimen in the herbarium of the Philadelphia Academy of Sciences consists of a single fragment of leaf about 8 by 50 ^{mm}, bearing only three sori. Both host and fungus fall somewhat short of perfect development.

A single glance at the uredospores of this species (*fig. 4, y*) shows that it could be associated with *P. rubella* (*P. Phragmitis*) only through ignorance of its real characteristics. The usually elongated, non-constricted, and often curved teleutospores are also distinctive (*fig. 4, z*).

This completes the list of species known to occur on Spartina, Phragmites, and Arundinaria in North America. There are only

[11] Trans. Amer. Phil. Soc. 4: 295.

two records[12] of any Uredineae being found on these hosts in South America, both given as *P. Phragmitis*, which I have had no opportunity to verify; and there is no record of such occurrence in Central America, Mexico, or the West Indies.

The parasitism of the Uredineae is so intimate that, when it is noticed that the three genera of hosts here studied belong to three widely separated sections of Gramineae, strong proof should have been required to show that any one species of rust could inhabit them all. In determining unnamed material the following key, based upon distinctions of host, position on the host, and the uredospores may prove serviceable. It is rare that some search in almost any specimen, at whatever time of year it may be gathered, does not disclose at least a few uredospores. The teleutospores are not so distinctive.

CHLORIDEÆ: *Spartina.*
- Sori arising from soft tissues (intercostal),
  - Uredospores with wall thin, colored, echinulate - *U. acuminatus.*
  - Uredospores with wall thick, pale, echinulate - - *P. Distichlidis.*
  - Uredospores with wall thickened above, colorless, tuberculate - - - - - - - - *P. Seymouriana.*
- Sori arising from hard tissues (supercostal),
  - Uredospores with wall thickened above, colorless, tuberculate - - - - - - - - *P. Fraxinata.*

FESTUCEÆ: *Phragmites.*
- Sori amphigenous, uredosori without paraphyses,
  - Uredospores with four equatorial pores - - - *P. rubella.*
- Sori amphigenous, uredosori with paraphyses,
  - Uredospores with indefinite, scattered pores - - *P. simillima.*

BAMBUSEÆ: *Arundinaria.*
- Sori hypophyllous, uredosori without paraphyses,
  - Uredospores with rather thick wall, echinulate - *P. Arundinariae.*

The four species on Spartina will shortly be published as exsiccati in the fourth fascicle of Arthur and Holways's *Uredineae Exsiccatae;* and the two species on Phragmites will be published somewhat later in the fifth fascicle of the same series.

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[12] Hedwigia 35:288. 1896. SPEGAZZINI'S Fungi Arg. 1221. 1899. Both reported on Phragmites from Argentine.